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Abstract

STOCHASTIC PROCESSES IN NUCLEAR REACTORS AND MEASUREMENT OF DYNAMIC PERFORMANCE CHARACTERISTICS

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Tabulations are given of the many specific methods of obtaining experimental information about stochastic processes along with data analysis techniques. These range from approximate and inexpensive approaches to very sophisticated and correspondingly precise methods. From this survey it is possible to arrive at certain guiding principles which assist one in selecting the proper method for his needs.

With both theoretical reactor dynamics and the mathematics of stochastic phenomena being highly developed, it is not surprising that in their combination a reliable theory of reactor noise exists. Thus for zero power reactors much success has been had in measuring the neutron lifetime, absolute power level, and shutdown reactivity margin. Data given for the Critical Experiment Station reactor shows that k-effective may be absolutely determined from the ratio of Fourier amplitudes at frequencies f_1 and f_2 of the randomly varying subcritical reactor flux. This is the basis for a simple meter which continually monitors the reactivity of a shutdown reactor as well as calibrates control rods.

In several power reactors it has been found that the source of the random fluctuations in n(t) is traceable to temperature fluctuations in the moderator coolant. In boiling reactors however these are converted to steam void fluctuations which provide the stochastic reactivity function exciting the reactor. Data along with methods of analysis to support these findings are given for the British DMTR, the U. S. Army ML-1 reactor, and the Elk River Reactor.

In the case of boiling reactors many noise spectra have been obtained from the Fourier analyses of the random fluctuations of n(t). These data are summarized and their characteristics tabulated in order to provide a background by which relative stability may be determined on future boiling reactors. Here reactor safety is studied by investigating a resonant frequency in the spectrum of Fourier amplitudes of n(t). It is shown that optimum and preferable analysis procedures exist because of this limited frequency band that is of interest.

While linear point reactor dynamics has been sufficient to characterize virtually all of the stochastic phenomena observed in reactors to date, both non-linear and spatial effects have also been investigated. For the former it has been found possible to generate pseudo-random reactivity excitation signals which measure the desired linear reactor characteristics in the presence of non-linear effects. Since very large power reactors may have regions which are loosely coupled dynamically, stochastic techniques have also been extended in order to investigate these reactors. Data from a zero power reactor having two loosely coupled slabs is given to demonstrate the application these methods have in studying spatial effects.